First Year Electricity & Magnetism **Classwork 7** **10 March 2008**

Numbers in italics refer to the Exercise number in the 12th Edition of Young & Freedman's "University Physics". Answers to odd-numbered questions are at the back of the book. Some useful formulae are given at the end of this sheet. This is a bit long, and we might not cover the material for the last question in time, but it is the last Classwork apart from the final Quiz on Magnetism.

1. [*28.36*] The figure shows, in cross section, several conductors that carry currents through the plane of the figure. The currents have the magnitudes $I_1 = 4.0\,\mathrm{A}$, $I_2 = 6.0\,\mathrm{A}$, and $I_3 = 2.0\,\mathrm{A}$, and the directions shown. Four paths, labeled a through d, are shown. What is the line integral $\oint \mathbf{B} \cdot \mathbf{d}\boldsymbol{\ell}$ for each path? Each integral involves going around the path in the counterclockwise direction. Explain your answers.

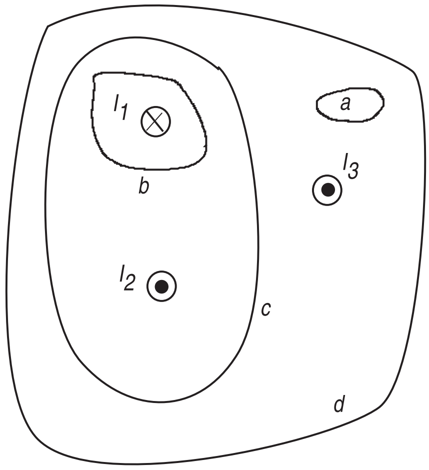

Figure from Problem 28.36

2. [*28.74*] A conductor is made in the form of a hollow cylinder with inner and outer radii a and b, respectively. It carries a current I, uniformly distributed over its cross section. Derive expressions for the magnitude of the magnetic field in the regions a) $r < a$; b) $a < r < b$; c) $r > b$. [You should also indicate on a sketch the direction of the magnetic field.]

3. [*28.49*] A long solenoid with 60 turns of wire per centimeter carries a current of 0.15 A. The wire that makes up the solenoid is wrapped around a solid core of silicon steel ($K_m = 5200$). (The wire of the solenoid is jacketed with an insulator so that none of the current flows into the core). a) For a point inside the core, find the magnitudes of i) the magnetic field $\mathbf{B}_0$ due to the solenoid current, ii) the magnetization $\mathbf{M}$, and iii) the total magnetic field $\mathbf{B}$. b) In a sketch of the solenoid and core, show the directions of the vectors $\mathbf{B}$, $\mathbf{B}_0$, and $\mathbf{M}$ inside the core.

4. A square loop of wire, with edges 20 cm, lies in the $x - y$ plane. A uniform magnetic field $\mathbf{B} = B(t)\hat{\mathbf{z}}$ varies with time according to $B(t) = 10^{-3} e^{-t/3}\,\mathrm{T}$, where t is time in seconds. a) Find the rate of change of magnetic flux through the loop, $d\Phi_B/dt$. b) By equating this to the negative of the electromotive force $\mathcal{E}$, show on a sketch the direction in which current will be driven around the loop. c) If the resistance of the loop is 100 Ω, find the current in the loop as a function of time.

Some possibly useful information and formulae:

$$\oint \mathbf{B} \cdot \mathbf{d}\boldsymbol{\ell} = \mu_0 I_{encl} = \mu_o \iint \mathbf{j} \cdot \mathbf{dA}$$

$$B = \frac{\mu_0 I}{2\pi r}$$

$$B = \mu_0 n I$$

$$B_x = \frac{\mu_0 I a^2}{2\left(x^2 + a^2\right)^{3/2}}$$

$$\mu = K_m \mu_0 = (\chi_m + 1)\mu_0$$

$$\mathbf{B} = \mathbf{B}_0 + \mu_0 \mathbf{M} = K_m \mathbf{B}_0$$

$$\frac{d\Phi_B}{dt} = -\mathcal{E}$$

Symbol	Value	Units
e	1.60×10^{-19}	C
μ_0	$4\pi \times 10^{-7}$	T m/A

Steve Schwartz, 10 March 2008